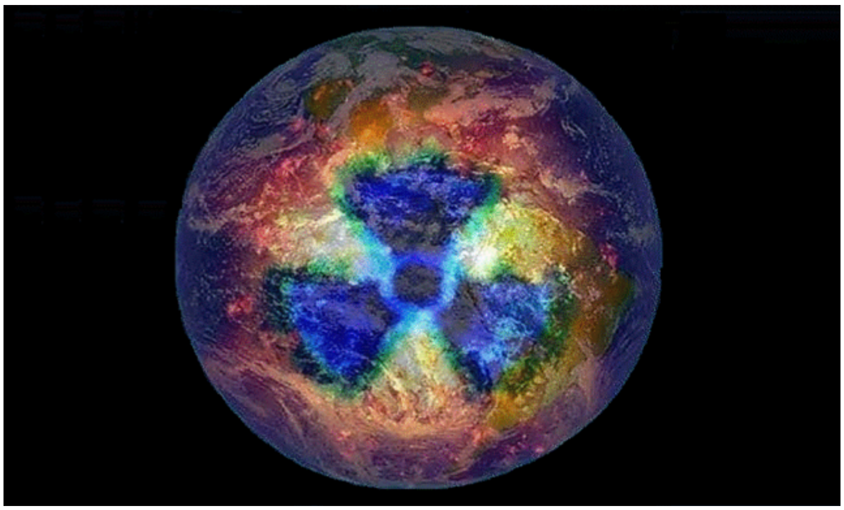
ORNL/TM-2017/460

Radiation Protection Research Needs Workshop: Summary Report



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I. SUMMARY

In order to protect humans and the environment when using ionizing radiation for the advancement and benefit of society, accurately quantifying radiation and its potential effects remains the driver for ensuring the safety and secure use of nuclear and radiological applications of technology. In the realm of radiation protection and its various applications with the nuclear fuel cycle, (nuclear) medicine, emergency response, national defense, and space exploration, the scientific and research needs to support state and federal radiation protection needs in the United States in each of these areas are still deficient.

Research and development in the field of radiation protection calls for cooperation among governmental agencies, emergency responders, research organizations, and the academic community. With this realization amidst atrophying national expertise in radiation protection, the ***Radiation Protection Research Needs Workshop*** was held in Oak Ridge, Tennessee on June 5-6, 2017. This workshop, hosted by the Oak Ridge Associated Universities (ORAU), the Oak Ridge National Laboratory (ORNL) Center for Radiation Protection Knowledge (CRPK), and the Health Physics Society (HPS), sought to facilitate critical dialogue among radiation protection stakeholders in the federal/state governments and the scientific community, including Department of Energy (DOE) national laboratories and academic institutions. The workshop totaled 84 attendees, who were each identified and invited to participate based upon their specialized and extensive experience in the field of radiation protection. Attendees were invited from 43 institutions/government programs (see list of attendees and participating organizations in *Appendix A*).

The following scientific research objectives in radiation protection were identified as a Critical National Radiation Protection Research Objective (CNRPRO):

1. Improve the **radiological protection** of workers, the public and the environment from radiation exposures due to occupational and public exposures, (nuclear) medical procedures, nuclear safety and security events, and space exploration.
2. Improve the **monitoring, detection** and **assessment** of radioactivity in the environment.
3. Better understand the **biological effects** of exposure to ionizing radiation (e.g. low-dose radiation effects) to allow optimization of the use of radiation, radiation protection, and how these effects/results will be integrated into regulatory policy.

II. APPROACH

During the workshop, input was solicited and dialogue conducted from the 84 attendees. The workshop featured:

- Presentations in two sessions entitled, ***Federal Research Needs****,* from seven federal agencies, private industry, independent research institutes, and international governmental research consortia from CONCERT/EURADOS;
- Panel discussion on ***Radiation Protection Needs in National Security****,* with representation from eight federal agencies; and
- Breakout discussion sessions representing nine critical research application areas *(Figure 1)*.

The final workshop agenda is provided in *Appendix B.*

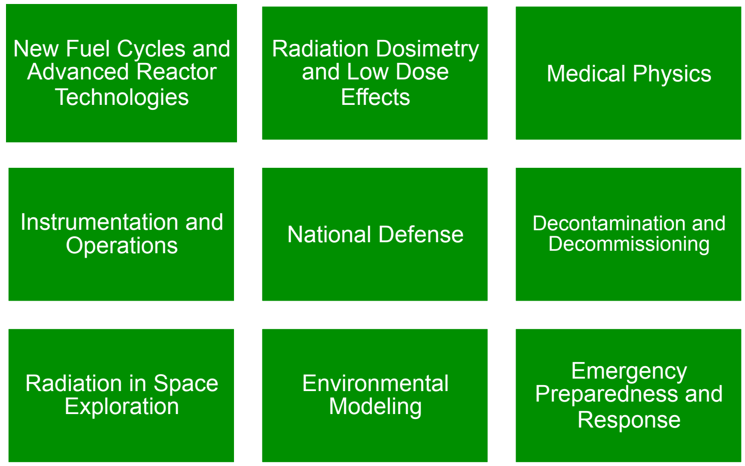

Figure 1. Breakout session tracks representing critical research needs at the Radiation Protection Research Needs Workshop

Presentations were delivered by representatives of the invited stakeholder organizations, primarily from federal government agencies. The stakeholders identified their critical scopes, which rely on radiation protection science, research and expertise and were asked to prioritize key research areas *(Table 1)*.

Table 1. Identification of Critical Path in Radiation Protection Research Needs.	
What research topics specific to your organization/expertise area, if critically addressed over the next several years, would significantly advance radiation protection?	• What is the current state-of-practice/use in this field? • What are the institutional/knowledge needs?
Where are the gaps between established practices/knowledge and identified needs?	• What is the ranking of each these needs as priorities given the importance of the need and the resources required to meet this priority? • Is there room for improvement/advancement/innovation within that system/technology? • Where are the areas of greatest uncertainty/risk?
How would you prioritize given the need of these advancements, and in consideration of the levels of risk/uncertainties to achieve these needs?	• What are the research needs in this field in the next 3-5 years? • How do we prioritize these needs in the broader long-term requirement?

III. KEY AREAS AND RESULTS

Based on the breakout discussions, areas of common research interest were identified as summarized below *(Table 2)*. Key themes from each of the breakout sessions are expanded in *Appendix C*.

Table 2. Identified Research Needs in Radiation Protection Research	
Refined radiation dose and risk estimates for occupational/public exposures, nuclear medicine, nuclear security, and space exploration: • Exposures at low doses • Rapid determination of dose due to external exposures and internal uptakes of radionuclides • Individualized vs. reference computational and biokinetic modeling • Non-cancer effects from radiation exposures • Secondary cancers from radiotherapy • Highly energetic, heavy ions at energies encountered in deep-space missions	**Improved radiation protective measures employing next-generation infrastructure and technologies:** • Optimization of shielding through enhanced computation and novel advances in material science • Application to next generation reactor (e.g. small modular reactors), fuel cycle (e.g. thorium), spent fuel and waste, and accelerator technology • Expanded use of remote handling and monitoring techniques (e.g. robotics) • Medical countermeasures to radiation exposure during nuclear/radiological events (bio- and physical dosimetry)
Development of novel radiation detection instrumentation that is: • Rugged, portable, and economical • Instrumentation that can detect alpha, beta, neutron, and gamma radiation • Harnessing advances in material science, data management, computational algorithms, and high performance computing	**Improved decontamination techniques focusing on:** • Urban environments following accident/incident scenarios • Volumetric contamination • Waste minimization
Modeling of complex environmental pathways including: • Atmospheric transport and urban plume modeling • Aquatic and terrestrial transport • Human-spread contamination	

IV. RECOMMENDATIONS AND PATH FORWARD

In addition to the data collected from this workshop, scientific literature, as well as reports and data from nongovernmental research institutions and government agencies, the information will be evaluated to prioritize the important scientific challenges that the radiation protection profession should address. Prioritization of challenges will be based on scientific merit, national relevance, impact on mission planning and completion, feasibility within given resource constraints, time sensitivity, and potential impact on complementary disciplines.

Each of the identified scientific challenges, with their associated research lines, will be developed as a separate section of a *Strategic Research Agenda*. Each will include a vision statement of what should be accomplished over the next 5, 10, and 20 years in that area of radiation protection. The development of a strategic research agenda involving all stakeholders will ensure that this living document will continue to reflect the radiation protection research areas critical to the completion of the nation's needs.

V. ACKNOWLEDGEMENTS

The chairs would like to acknowledge the invaluable support provided by colleagues and sponsors in the actuation of this workshop.

Organizers: Kelly Nist (ORAU), Diane Kosier (ORNL), Greg Zimmerman (ORNL), Stan Wullschleger (ORNL).

Recorders: Cailin O'Connell (TAMU/ORNL), Kathryn Bales (UTK/ORNL), Linda Hodges (ORAU), Karin Jessen (ORAU), and Mike Mahathy (ORAU).

IT Support: Nicholas Walker (ORAU)

Sponsors: ORAU, Georgia Institute of Technology – George G. Woodruff School of Mechanical Engineering, and UT-Battelle.

VI. TECHNICAL POINTS OF CONTACT

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APPENDIX A. WORKSHOP AGENDA

Monday, June 5, 2017			
Time	**Event**	**Presenter/Moderator**	**Location**
7:30am-8:00am	**Registration & Coffee/Breakfast**		Pollard Lobby
8:00am-8:15am	**Introductory Comments**	Eric Abelquist (ORAU)	Pollard Auditorium
8:15am-8:30am	**Research Needs in Radiation Protection - Roadmap**	Nolan Hertel (Gatech/ORNL)	
8:30am-9:00am	**Plenary 1**	Dick Toohey (NCRP)	
9:00am-9:30am	**Plenary 2**	Kathy Higley (OSU/NCRP)	
9:30am-12:00pm 9:30am-10:00am	**Federal Research Needs I** **Federal Research: Introduction**	Chairs: Mike Boyd (EPA) Jason Davis (ORAU) Mike Boyd (EPA)	
10:00am-10:20am	**BREAK**		
10:20am-10:40am	**Environmental Protection Agency**	Lowell Ralston (EPA)	Pollard Auditorium
10:40am-11:00am	**Nuclear Regulatory Commission**	Cynthia Jones (NRC)	
11:00am-11:20am	**Department of Energy**	Pat Worthington (DOE)	
11:20am-11:40am	**National Cancer Institute**	Choonsik Lee (NCI)	
11:40am-12:00pm	**Food and Drug Administration**	Stanley Stern (FDA)	

12:00pm-1:00pm	**LUNCH**		
1:00pm-2:15pm	**Breakout Session #**1 • Track 1-1: Radiation Protection Issues with New Fuel Cycles and Advanced Technologies • Track 1-2: Dosimetry	Track 1-1 Chairs: Cynthia Jones (NRC), Bojan Petrovic (Gatech) Track 1-2 Chairs: Wes Bolch (UFL), Shaheen Dewji (ORNL)	Pollard Auditorium Pollard 240
2:15pm-2:30pm	**BREAK**		
2:30pm-3:45pm	**Breakout Session #2** • Track 2-1: Radiation Protection in Medical Physics • Track 2-2: Instrumentation and Operations	Track 2-1 Chairs: Wayne Newhauser (LSU), Niek Schreuder (Provision) Track 2-2 Chairs: Mike Stafford (ORNL), Frazier Bronson (Mirion)	Pollard Auditorium Pollard 240
3:45pm-4:00pm	**BREAK**		
4:00pm-5:00pm	**Breakout Sessions 1 & 2: Recap and Discussion**	Tracks 1 and 2 Chairs	Pollard Auditorium
5:00pm-7:00pm	**Cocktail Reception**		Pollard Lobby

Tuesday, June 6, 2017			
Time	**Event**	**Presenter/Moderator**	**Location**
7:30am-8:00am	**Registration & Coffee/Breakfast**		Pollard Lobby
8:00am-8:30am	**European Approach - CONCERT**	Werner Ruehm (EURADOS)	Pollard Auditorium
8:30am-9:45am	**Panel – Radiation Protection Needs in National Security** • National Nuclear Security Administration • Department of Homeland Security • Centers for Disease Control and Prevention • Department of Defense	Chairs: Craig Moss (ORNL), Andrew Scott (DHS) Panelists: • Dan Blumenthal (NNSA) • Adela Salame-Alfie (CDC) • Luis Benevides (DOD-Navy) • Jama Van Horne-Sealy (DOD-Army) • Ricardo Reyes (DNDO) • Brendan Palmer (FEMA)	
9:45am-10:00am	**BREAK**		
10:00am-11:00am 10:00am-10:20am	**Federal Research Needs II** **National Aeronautics and Space Administration**	Chair: Barry Fountos (DOE) Eddie Semones (NASA)	Pollard Auditorium
10:20am-10:40am	**Electric Power Research Institute**	Don Cool (EPRI)	
10:40am-11:00am	**Radiation Protection Challenges in Low Dose**	Isaf al-Nabulsi (DOE)	

Tuesday, June 6, 2017			
Time	**Event**	**Presenter/Moderator**	**Location**
11:00am-12:00pm	**Low Dose Discussion**	Chairs: John Boice (NCRP), Michael Bellamy (ORNL)	Pollard Auditorium
12:00pm-1:00pm	**LUNCH**		
1:00pm-2:15pm	**Breakout Session #3** Track 3-1: Radiation Protection Needs in National Defense Track 3-2: Decontamination and Decommissioning	Track 3-1 Chairs: Luis Benevides (DOD-Navy), Jama VanHorne-Sealy (DOD-Army) Track 3-2 Chairs: Wendy Cain (DOE), John Cardarelli (EPA)	Pollard Auditorium Pollard 240
2:15pm-2:30pm	**BREAK**		
2:30pm-3:45pm	**Breakout Session #4** Track 4-1: Radiation in Space Track 4-2: Environmental Modeling Track 4-3: Radiation Protection Needs in Emergency Response	Track 4-1 Chairs: Eddie Semones (NASA), Wouter de Wet (UTK) Track 4-2 Chairs: Nicole Martinez (Clemson), Jerry Hiatt (NEI) Track 4-3 Chairs: John Crapo (NNSA), Adela Salame-Alfie (CDC)	Pollard 240 Pollard 242 Pollard Auditorium
3:45pm-4:00pm	**BREAK**		
4:00pm-5:00pm	**Breakout Sessions 3 & 4 Recap and Discussion**	Tracks 3 and 4 Chairs	Pollard Auditorium
5:00pm-5:15pm	**Closing Remarks**	Eric Abelquist Nolan Hertel	Pollard Auditorium

APPENDIX B. LIST OF ATTENDEES

First Name	Family Name	Affiliation
Vitaly	Nagy	AFRRI
Charles	Woodruff	AFRRI
Natalia	Ossetrova	AFRRI/USUHS
Kara	Beharry	Auburn University
Frazier	Bronson	Canberra
Adela	Salame-Alfie	CDC
Brendan	Palmer	Chainbridge Technologies
Timothy	Devol	Clemson University
Nicole	Martinez	Clemson University
Tom	Johnson	Colorado State University
Ruth	Mcburney	CRCPD
Jared	Thompson	CRCPD
Andrew	Scott	DHS
Ricardo	Reyes	DHS/DNDO
Wendy	Cain	DOE
Barrett	Fountos	DOE
Isaf	Al-Nabulsi	DOE-AU-10
Daniel	Blumenthal	DOE/NNSA
John	Crapo	DOE/NNSA
Rathnayaka	Gunasingha	Duke University
Terry	Yoshizumi	Duke University
Clay	Easterly	Easterly Scientific
Donald	Cool	ERPI
Derek	Jokisch	Francis Marion University
Nolan	Hertel	Georgia Institute of Technology
Chris	Wang	Georgia Institute of Technology
Gregory	Nichols	HDIAC
Werner	Ruehm	Helmholtz Center Munich
Craig	Little	Health Physics Society
Brett	Burk	Health Physics Society
David	Connolly	Health Physics Society
Richard	Brey	Idaho State University
Bernadette	Kirk	Kirk Nuclear Information Services
Luiz	Bertelli	Los Alamos National Laboratory
John	Bliss	Los Alamos National Laboratory
Wayne	Newhauser	Louisiana State University
Richard	Toohey	M. H. Chew & Associates
Choonsik	Lee	National Institutes of Health

First Name	Family Name	Affiliation
John	Boice	NCRP/Vanderbilt
Jerry	Hiatt	Nuclear Energy Institute
Eric	Abelquist	ORAU
Donna	Cragle	ORAU
Jason	Davis	ORAU
Elizabeth (Betsy)	Ellis	ORAU
Cathy	Fore	ORAU
Ashley	Golden	ORAU
Derek	Hagemeyer	ORAU
Carol	Iddins	ORAU
Kelly	Nist	ORAU
Adayabalam	Balajee	ORAU
Kathryn	Higley	Oregon State University
Douglas	Peplow	Oak Ridge National Laboratory
Shaheen	Dewji	Oak Ridge National Laboratory
Bradley	Rearden	Oak Ridge National Laboratory
Greg	Zimmerman	Oak Ridge National Laboratory
Michael	Bellamy	Oak Ridge National Laboratory
Keith	Eckerman	Oak Ridge National Laboratory
Robert	Grove	Oak Ridge National Laboratory
David	Holcomb	Oak Ridge National Laboratory
Rich	Leggett	Oak Ridge National Laboratory
Craig	Moss	Oak Ridge National Laboratory
Cecil	Parks	Oak Ridge National Laboratory
Michael	Stafford	Oak Ridge National Laboratory
Kathryn	Bales	Oak Ridge National Laboratory
Jason	Harris	Purdue University
Nicholas	Dainiak	REAC/TS
Craig	Williamson	SCUREF
Henry	Tran	SLAC National Accelerator Laboratory
Cailin	O'Connell	Texas A&M University/ORNL
John	Cardarelli	U.S. Environmental Protection Agency
Lowell	Ralston	U.S. Environmental Protection Agency
Michael	Boyd	U.S. Environmental Protection Agency
Michael	Noska	U.S. FDA
Stanley	Stern	U.S. FDA Center for Drug Evaluation & Research
Kevin	Hsueh	U.S. Nuclear Regulatory Commission
Cynthia	Jones	U.S. Nuclear Regulatory Commission
Wesley	Bolch	University of Florida
Pasquale	Fulvio	University of Puerto Rico

First Name	Family Name	Affiliation
Wouter	De Wet	University of Tennessee, Department of Nuclear Engineering
Laurence	Miller	University of Tennessee, Department of Nuclear Engineering
Robert	Cherry	U.S. Army
Carlos	Corredor	U.S. Army Public Health Center
Jama	Vanhorne-Sealy	U.S. Army USANCA
Luis	Benevides	U.S. Navy

APPENDIX C. BREAKOUT SESSION THEMES

New Fuel Cycles/Reactors	Dosimetry/Risk	Medical Physics	Instrumentation and Operations	Decontamination and Decommissioning
• Comparison of dose impact to existing cycles • Modeling and planning for radiological emergencies • Waste handling and disposal • Variation in environmental pathways • Incorporation of new shielding technologies into reactor design	• Improvement of radiation risk estimates from biological data • Determination of cancer risk due to exposures at low dose • Personalization of dosimetry in medical applications • Rapid and accurate dose assessment during radiological emergencies • Refinement of the use of theoretical dose concepts and quantities • Enhancement of radiation measurement systems • Development of environmental dosimetry for non-human biota	• Improve methods for calculating dose and corresponding risk of radiogenic cancer • Develop methods for personalized radiation dose and risk calculations suitable for clinical applications • Improve methods for calculating dose and corresponding non-cancer late effects • Improve simulation methods to model advanced-, emerging-, and next-generation radiation therapy and imaging technologies	• Improved neutron instrumentation • Indoor position logging • Improved field-appropriate spectroscopy • Combination (radiological and chemical) detectors • Direction-specific detectors • Improvement to instrument ruggedness • Instrumentation that can detect alpha, beta, neutron, and gamma radiation • Development of instruments that are hardened against radiation damage • Definition and pathway for Very Low Level Waste	• Development of risk-based cleanup levels using ecological system transport • Characterization of radon for in-situ mines • Improved characterization technologies for sub-surface soils and groundwater • Novel decontamination techniques • Development of remote handling techniques • Determination of confounding effects of radiological and chemical exposures • Waste volume reduction • Determination of volumetric contamination • Waste disposal

Space Radiation	National Defense	Emergency Response	Environmental Modeling
• Optimization of shielding thickness • Secondary radiation produced in shielding • Cross sections for heavy, energetic particle interactions • Comparative dose response studies • Individual, genetic-based risk profiles • Central nervous system damage effects • Radiogenic cardiovascular effects • Low dose rate effects from all (incl. heavy) ions • Improved astrophysical models to minimize dose based on mission timing • On-site construction of shielding	• Determination of protection factors for vehicles and structures • Improved radiation transport codes that allow incorporation of CAD data • Biodosimetry for rapid triage • Dosimetry models for combat animals • Personnel performance degradation from medical countermeasures • Development of coatings that inhibit contamination due to fallout • Portable, rugged detection instrumentation • Unmanned detection robots • Urban plume modeling • Hardening of electronics against radiation damage	• Atmospheric dispersion modeling • Contaminant migration modeling • Population dose estimation • Dose assignment for emergency response workers • Biodosimetry for rapid triage • Improved bioassay for alpha emitters • Assay for low-energy contaminants • Post-event decontamination • Urban environment activation • Directional radiation detectors	• Radionuclide fate and transport modeling • Incorporation of sport hunting and wild plant foraging in pathway models • Identification of indicator species within each climatological area • Confounding effects due to chemical and physical stressors in conjunction with radiological exposures • Determination of biological effects risk due to exposures at low dose